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ILLINOIS NATURAL HISTORY SURVEY

PRELIMINARY INVESTIGATIONS INTO
INDIANA BAT (*MYOTIS SODALIS*) AND GRAY BAT (*MYOTIS GRISESCENS*)
OCCURRENCE, DISTRIBUTION AND STATUS IN THE
SHAWNEE NATIONAL FOREST, ILLINOIS

FINAL REPORT

20 FEBRUARY 1986

Section of Faunistic Surveys and Insect Identification Technical Report

1986(1)

by
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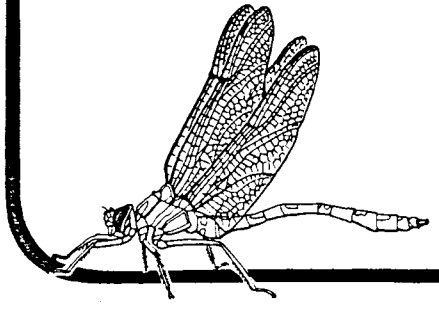

Prepared for

Shawnee National Forest
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ABSTRACT

Preliminary investigations into the occurrence, distribution and status of *Myotis sodalis* (Indiana bat) and *Myotis grisescens* (gray bat) were conducted within the Shawnee National Forest purchase unit boundaries. Between 3 June and 2 October 1985 seven surface sites were mist netted and three cave entrances were trapped for bats. These efforts resulted in the capture of 119 bats representing nine species.

Four *Myotis sodalis* were captured over creeks and rivers and nine were trapped at two cave entrances. Two *Myotis grisescens* were captured over a river and 16 were trapped at one cave entrance. The results of this preliminary investigation clearly indicated that *Myotis sodalis* and *Myotis grisescens* utilize habitats in the Shawnee National Forest to a greater extent than had been believed previously. Other species of bats captured either over surface streams or at cave and/or mine entrances included: *Myotis lucifugus* (n=30), *Myotis keenii* (n=8), *Pipistrellus subflavus* (n=30), *Eptesicus fuscus* (n=7), *Plecotus rafinesquii* (n=1), *Lasiurus borealis* (n=11), and *Lasiurus cinereus* (n=1).

A total of 13 *Myotis sodalis* and 18 *Myotis grisescens* were banded during this study as part of long-term, ecological investigations of these two species in Illinois. An additional 19 bats were banded at one cave entrance as part of these state-wide studies.

Suggested guidelines for evaluating the suitability of riparian habitats as maternity sites for *Myotis sodalis* were field tested at twelve mist netting sites throughout Illinois; two of these sites were located within the Shawnee National Forest. Definite problems emerged concerning the evaluation criteria used to measure life requisite values. Further studies and field testing are needed to determine maternity site requirements of *Myotis sodalis* before potential habitat values can be accurately evaluated.

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INTRODUCTION

As of September 30, 1984, approximately 261,500 acres were administered by the Shawnee National Forest as part of the National Forest system (Draft Environmental Impact Statement, Shawnee National Forest 1985). The Shawnee National Forest is located in extreme southern Illinois and encompasses some of the most rugged topography in the state. Forested rolling hills, lakes, streams and spectacular rock outcroppings stretch across the Shawnee from the Mississippi River on the west to the Ohio on the east.

Paleozoic limestones and dolomites of southern Illinois are conducive to cave formation. A large number of active and abandoned mines are scattered across southern Illinois. Caves and mines are necessary to some species of bats which utilize them as hibernacula (sites of hibernation). Eight species of bats have been recorded historically from caves and mines in southern Illinois (Cory 1912; Miller and Allen 1928; Elder 1946; Parmalee and Smith 1954; Smith and Parmalee 1954; Layne 1958; Pearson 1962; Pearson and Barr 1962; Hall and Wilson 1966; Whitaker 1975; Whitaker and Winter 1977). Those species of cave bats previously reported from mines and caves in the Shawnee National Forest are *Myotis sodalis* (Indiana bat), *Myotis grisescens* (gray bat), *Myotis lucifugus* (little brown bat), *Myotis keenii* (Keen's Myotis), *Myotis austroriparius* (southeastern Myotis), *Eptesicus fuscus* (big brown bat), *Pipistrellus subflavus* (eastern pipistrelle), and *Plecotus rafinesquii* (Rafinesque's big-eared bat).

Wooded ravines and ridgetops and forested bottomlands, combined with sinuous creeks and rivers, provide vegetationally diverse summer habitat for many bats. Species which utilize summer habitats in the Shawnee National Forest, in addition to those species mentioned above, include *Lasiurus borealis* (red bat), *Lasiurus cinereus* (hoary bat), *Lasionycteris noctivagans* (silver-haired bat), and *Nycticeius humeralis* (evening bat). These four species are categorized as tree bats and most migrate seasonally as an alternative to hibernation.

Two species of bats, *Myotis sodalis* and *Myotis grisescens*, are federally listed endangered species (50 CFR 17, subpart B, subsection 17.11). However, all species of bats occurring in Illinois are protected by law (Illinois Wildlife Code, as revised, Chapter 61, article ii, section 2.2), with *Myotis sodalis* and *Myotis grisescens* listed as state endangered. These endangered species of bats are seriously threatened by human land use practices. Alteration and destruction of habitat resulting from stream channelization, lake inundation, agricultural clearing, road and utility construction, deforestation and urban expansion all threaten the continued existence of Indiana and gray bat populations. Pesticide-induced mortality of insectivorous bats has been well documented (Mohr 1972; Geluso *et al.* 1976; Clark *et al.* 1983) and has undoubtedly contributed to declining populations of Indiana and gray bats. There are many unanswered questions concerning possible adverse impacts from water quality deterioration and unavailability of insect prey.

Shawnee National Forest lands, as well as other publicly managed lands, may someday be the only remaining areas of suitable habitat in Illinois for these endangered species. Regulation W2 (Secretary of Agriculture) provides for the formulation of management plans in cooperation with fish and game authorities of respective states for securing and maintaining desirable populations of wildlife species on National Forest lands. Taking this charge into consideration, this preliminary study was designed with the following objectives:

(1) To make preliminary investigations into the occurrence, distribution, and status of Indiana and gray bat populations within the Shawnee National Forest purchase boundaries.

(2) To identify specific areas within the Shawnee National Forest where more extensive investigations of bat fauna could be focused.

(3) To conduct initial field testing of a model for evaluating Indiana bat summer habitat within Shawnee National Forest purchase unit boundaries.

The results contained in this preliminary investigation clearly indicate that *Myotis sodalis* and *Myotis grisescens* utilize habitats occurring in the Shawnee National Forest to a greater extent than had been believed previously. Further studies are needed to more fully develop management recommendations to ensure the continued existence of these endangered species in the Shawnee National Forest, thereby contributing to nation-wide recovery efforts.

DESCRIPTION OF STUDY AREAS

The original project proposal for preliminary investigations indicated that four surface locations would be mist netted for bats. Additionally, trapping at one cave and one mine entrance within the Shawnee National Forest would be conducted. However, a total of seven surface sites were mist netted and three cave entrances were trapped (Figure 1). The seven stream sites were: (1) Wallace Branch (Hardin County); (2) Bay Creek, (3) Lusk Creek, and (4) Big Grand Pierre Creek (Pope County); (5) Rock Branch (Saline County); (6) Cache River (Johnson County); and (7) Cedar Creek (Jackson County). The three cave entrances sampled by bat trapping techniques were: (8) Cave Spring Cave (Hardin County); (9) Rich's Cave (Union County); and (10) Ava Cave (Jackson County). All of these study sites were located within the Shawnee National Forest purchase unit boundaries and are discussed in greater detail.

Descriptions of mist net sites and stream characteristics were included to contribute to our understanding of summer habitat suitability for bat fauna. Past studies have shown that bats (particularly Indiana bats) forage for insects over riparian habitats (Humphrey *et al.* 1977; Gardner and Gardner 1980; LaVal and LaVal 1980; Gardner and Taft 1983, 1984), with a preference for contiguous woodlands and trees forming a canopy over streams and rivers. The Indiana Bat Recovery Team (USDI 1983) has established a rating system

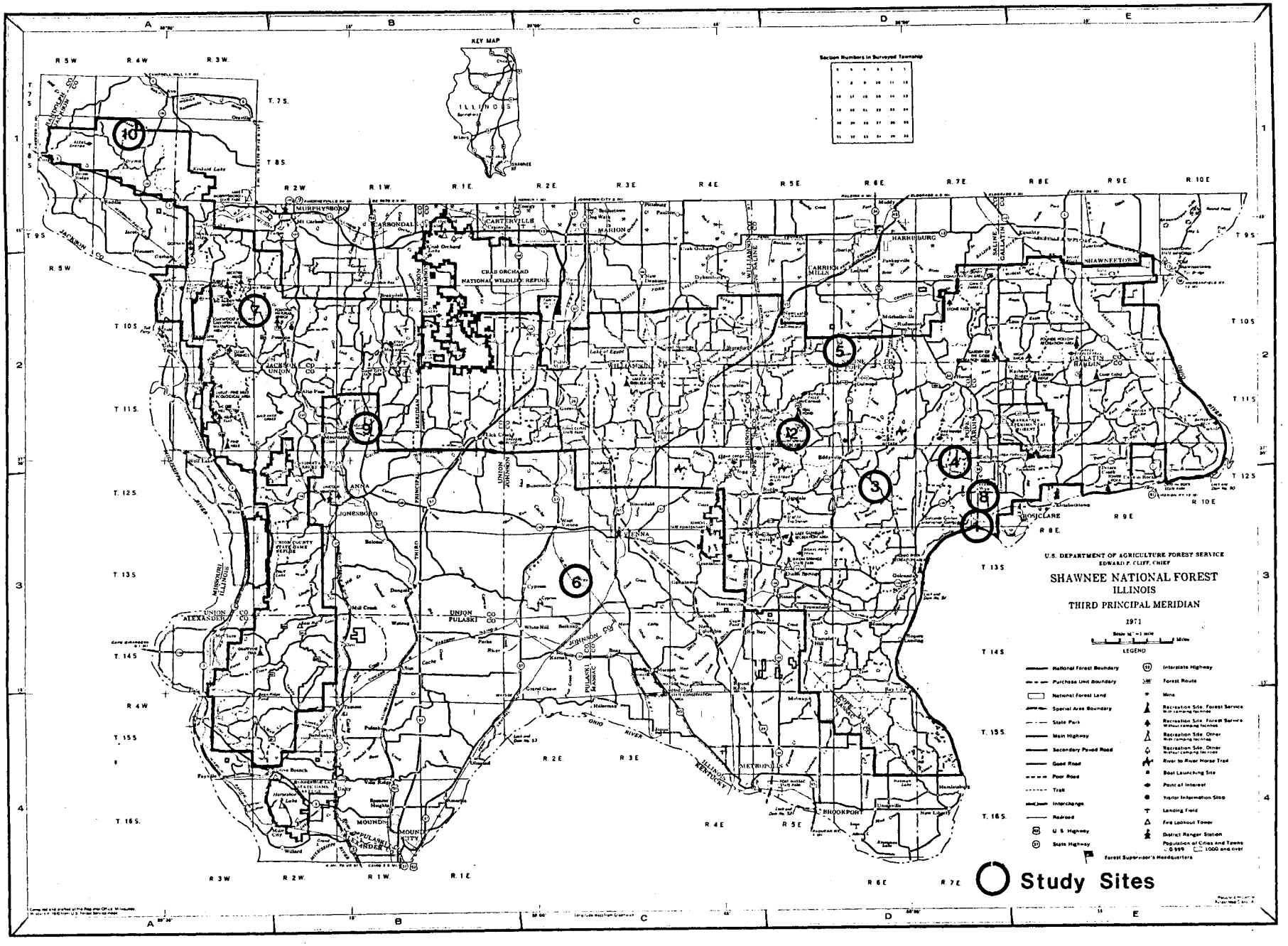

Figure 1. Mist netting sites (1-7) and cave trapping sites (8-10) sampled during preliminary investigations of Myotis sodalis and Myotis grisescens occurrence, distribution and status on the Shawnee National Forest.

which qualitatively categorizes riparian habitat in relation to its suitability for foraging Indiana bats (based on reported habitat preferences). This classification system was applied as follows:

Category I-Few or no trees on either bank.
" II-Scattered small trees on either bank.
" III-Mature trees on one bank only.
" IV-Mature trees on both banks, but not extending past stream banks.
" V-Mature trees extending more than 3 m past stream bank.

The vegetation and stream categorization at surface sites was visually assessed by walking both upstream and downstream of the netting location until the site was adequately characterized to meet the study objectives. In addition, the surrounding vegetation of each netting site was briefly described.

Surface Mist Netting Sites

(1) Wallace Branch Site
Hardin County
T12S, R7E, SE/4-NW/4-NE/4-SE/4 Section 35
(Shetlerville 7.5' quadrangle)
Figure 1

Four 12.8 m mist nets, suspended between a pair of 9.2 m high poles, were positioned across the western portion of Wallace Branch. At this netting location Wallace Branch has a deep main channel flanked by shallower areas. The Ohio River commonly backfloods this portion of Wallace Branch, inundating a wide area of the channel. Since the main channel was too deep to wade safely, the east pole was placed in 0.75 m deep water and the west pole on dry land at a point approximately 8 m from the edge of the water. In this manner, a portion of the air space above the branch was covered.

Vegetation in the immediate stream channel was primarily dead trees. Repeated inundation by backflooding from the Ohio River has killed virtually every tree on the low banks of the branch. Some surviving trees included green ash (*Fraxinus pennsylvanica*) and silver maple (*Acer saccharinum*). The mist nets were essentially positioned in the midst of dead trees.

Wallace Branch was approximately 12 m wide at the narrowest point in its lowland channel (Table 1). Stream flow was unrecognizable at this site and the branch more closely resembled a slough. The bottom was mud and released bubbles of methane gas when disturbed.

Table 1. Vegetation classification and stream characteristics of Wallace Branch Site, Hardin County, Illinois.

Vegetation Category	Width of Vegetation (m) west	east	Stream Channel Characteristics: Width (m)	Depth (m)	Bottom Type	Riffle/Pool Frequency	Man-made Alterations
IV	40	50+	12	15+	mud	continuous pool	railroad trestle

(2) Bay Creek Site (Bell Smith Springs Scenic Area)
Pope County
T11S, R5E, NW/4-NW/4-NW/4-SW/4 Section 34
(Stonefort 7.5' quadrangle)
Figure 1

Four 12.8 m mist nets, suspended between a pair of 9.2 m high poles, were positioned across the creek. The east pole was placed at the base of a steep bank with tall, mature trees towering above. The west pole was placed partially up a more gentle slope of the bank, beneath overhanging branches of a large blue beech (*Carpinus caroliniana*). Bay Creek was partially canopied by the tall, mature blue beech and sugar maple (*Acer saccharum*), but the stream was too wide at the netting site to allow a complete canopy to form.

This area of Bay Creek is known as Bell Smith Springs Scenic Area (Evers and Page 1977). Steep cliffs and massive sandstone boulders line the banks of the creek. The stream banks are dominated by blue beech and sugar maple, but oak (*Quercus* sp.) and hickory (*Carya* sp.) dominate the upper slopes and ridgetops. Seedling sugar maple dominate the shrub layer, but flowering dogwood (*Cornus florida*), beech, and tulip tree (*Liriodendron tulipifera*) seedlings are characteristic along the stream (Mohlenbrock 1968).

Bay Creek is characterized by deep, calm, clear pools which give way to shallow riffles and waterfalls. The stream was approximately 11 m wide at the netting site and 0.5 m deep (Table 2). The substrate was predominantly rubble and large rocks, but areas of leaf and twig debris was not uncommon. The nets were positioned across the middle of a calm pool with a rocky bottom.

Table 2. Vegetation classification and stream characteristics of Bay Creek Site, Pope County, Illinois.

Vegetation Category	Width of Vegetation (m) west	east	Stream Channel Characteristics: Width (m)	Depth (m)	Bottom Type	Riffle/Pool Frequency	Man-made Alterations
V	100+	100+	11	0.5	rock	30 m	developed for recreation

(3) Lusk Creek Site (Eddyville Blacktop Bridge)
Pope County
T12S, R6E, SW/4-SW/4-NE/4-SE/4 Section 16
(Waltersburg 7.5' quadrangle)
Figure 1

Two 12.8 m nets, suspended between a pair of 6.2 m high poles, were positioned across Lusk Creek. These poles fit perfectly beneath the Eddyville blacktop bridge and the nets could be raised up to the bottom of the bridge. Positioning the nets in this manner is a successful technique (Gardner and Taft 1983; 1984). The south pole was placed against the flat-walled concrete abutment of the bridge. The north pole was positioned in the stream approximately 3 m from the opposite abutment. An additional 12.8 m mist net was placed adjacent to the high nets, but was stretched barely above the water surface to more completely close off the air space beneath the bridge.

Vegetation on either bank west of the bridge was relatively sparse because of hayfields. A small patch of isolated woods, at most 40 m wide, occurred on both of these banks. The woods east of the bridge were much more extensive with more upland slopes. Tall cottonwood (*Populus deltoides*) and sycamore (*Platanus occidentalis*) comprised the dominant canopy vegetation, but some upland species such as oak, elm (*Ulmus* sp.) and hickory were common.

Lusk Creek, in the vicinity of the netting site, had some calm pools connected by fast riffles (Table 3). The 16 m wide stream channel was deeply entrenched and some small sand islands were established. The bottom was rocky rubble with some sand.

Table 3. Vegetation classification and stream characteristics of Lusk Creek Site, Pope County, Illinois.

Vegetation Category	Width of Vegetation (m)		Stream Channel Characteristics				
	north	south	Width (m)	Depth (m)	Bottom Type	Riffle/Pool Frequency	Man-made Alterations
V	40+	40+	16	0.4	rock,sand, rubble	30+	highway bridge

(4) Big Grand Pierre Creek Site
Pope County
T12S, R7E, SW/4-SE/4-SW/4-NE/4 Section 9
(Shetlerville 7.5' quadrangle)
Figure 1

Four 18.3 m mist nets, suspended between a pair of 9.2 m high poles, were positioned across Big Grand Pierre Creek at a point 75 m upstream (north) of a low water bridge. The east pole was placed beneath and between overhanging

branches of sycamore, elm and box elder (*Acer negundo*). This bank was rather steep with exposed roots. The west pole was positioned beneath the overhanging branches of an oak.

Vegetation at the netting site was bottomland hardwoods. An occassional tall sycamore and cottonwood extended above the shorter canopy species. The creek was far too wide to allow tree branches to intertwine above the stream and create a complete canopy. However, the branches of most trees overhung the creek, creating a well defined flyway.

Big Grand Pierre Creek was a clear, swiftly flowing stream of very good water quality. The 20 m wide stream channel had a rocky, rubble and sand bottom at the netting site (Table 4). Long calm pools were connected by swift riffles.

Table 4. Vegetation classification and stream characteristics of Big Grand Pierre Creek Site, Pope County, Illinois.

Vegetation Category	Width of Vegetation (m) west	Width of Vegetation (m) east	Stream Channel Characteristics: Width (m)	Depth (m)	Bottom Type	Riffle/Pool Frequency	Man-made Alterations
V	100+	100+	20	0.25	rock,sand, rubble	80+	low water bridge

(5) Rock Branch Site
Saline County
T10S, R6E, SE/4-SE/4-SE/4-NW/4 Section 31
(Eddyville 7.5' quadrangle)
Figure 1

Four 12.8 m mist nets, suspended between a pair of 9.2 m high poles, were positioned across a bend of the stream. The north pole was placed beneath the branches of a large river birch (*Betula nigra*). This bank sloped more gently than the south bank and was entirely sandy. The south pole was positioned between two large overhanging elm and some smaller river birch. This south bank was rubble with many exposed roots. An additional 5.5 m net was stretched tightly between two small poles and suspended barely above the surface of a calm pool 4 m west of the high net set.

Vegetation at this site was comprised largely of upland species, dominated by oak and hickory. However, an occassional sycamore and river birch occurred along the immediate branch. The trees along either bank overhung the stream channel to such a degree that areas of the flyway were partially obstructed. Some forest clearings, wildlife food plots and pasture occurred nearby.

Rock Branch was a small stream which averaged 8 m wide in the area of the netting site (Table 5). Small pools of less than 0.5 m depth were connected by trickling flow on the date of netting. Rubble and sand comprised the bottom and sand accumulated in some areas, forming banks. Flash flood debris was evident in many areas. Off-road vehicles have made trails in the channel of this small branch.

Table 5. Vegetation classification and stream characteristics of Rock Branch Site, Pope County, Illinois.

Vegetation Category	Width of Vegetation (m) north	south	Stream Channel Characteristics: Width (m)	Depth (m)	Bottom Type	Riffle/Pool Frequency	Man-made Alterations
V	100+	100+	8	0.5	rubble, sand	8+	ORV trails

(6) Cache River Site (Boss Island)
Johnson County
T13S, R2E, NE/4-SE/4-NW/4-SW/4 Section 24
(Karnak 7.5' quadrangle)
Figure 1

Four 18.3 m mist nets, suspended between a pair of 9.2 m high poles, were positioned across the Cache River at the eastern end of Boss Island. An old, well-established ford occurs across the river and has been modified with oversized rubble. The poles were positioned on opposite banks directly over the ford. Trees on either bank slightly overhung the netting poles. An additional 18.3 m mist net was stretched tightly between two poles and placed adjacent to the downstream (east) side of the high net set. This method more completely covered the remaining air space between the bottom of the high net set and the water surface.

Vegetation on the south bank of this netting site had been removed in the past. Thick stands of cottonwood were planted and form the dominant canopy species. Large green ash, river birch and sycamore border the stream. However, the north slope is more upland and species components characteristic of steep, dry slopes can be found there. Large green ash have fallen across the river in several places.

The Cache River in this location is a very sluggish stream. The approximately 18 m wide stream would normally have been a continuously flowing pool, but the artificial ford across the river created a riffle area (Table 6). The substrate was mud with oversized rubble in the ford beneath the nets. The banks were steep mud and heavily eroded in areas with exposed roots.

Table 6. Vegetation classification and stream characteristics of Cache River (Boss Island) Site, Johnson County, Illinois.

Vegetation Category	Width of Vegetation (m) north	south	Stream Channel Characteristics: Width (m)	Depth (m)	Bottom Type	Riffle/Pool Frequency	Man-made Alterations
V	100+	50+	18	0.2	mud	artificial riffle	ford across river

(7) Cedar Creek Site
Jackson County
T10S, R2W, SW/4-NE/4-NE/4-NW/4 Section 18
(Pomona 7.5' quadrangle)
Figure 1

Two 9.1 m mist nets, suspended between a pair of 6.2 m high poles, were positioned across the creek at a point 75 m downstream (west) of the county road bridge over the creek. The south pole was placed at the base of a steep 4 m high mud bank. The limbs of predominantly immature silver maple and elm slightly overhung this netting pole. The north pole was placed near the middle of the more gently sloping mud bank on the north. A large cottonwood overhung this pole. An additional 5.5 m mist net was stretched across the creek adjacent to the upstream (east) side of the high net set.

Vegetation along both banks of the netting site was characteristic of bottomland forests. An occassional sycamore and cottonwood protruded above the other trees. Tree species commonly seen at this site included box elder, elm and silver maple. The vegetation on the south bank was interrupted by a powerline right-of-way clearing; a strip of vegetation only 15 m wide remained along this bank.

Cedar Creek is a very sluggish stream with a mud and silt bottom (Table 7). The 9 m wide stream channel was deeply entrenched with steep mud banks and the appearance of a channelized stream. Although some flow was evident, the creek at the netting site was predominantly a continuous pool. Flash flood debris was common and bubbles of methane gas escaped when the bottom was disturbed. The water quality of Cedar Creek was questionably fair.

Table 7. Vegetation classification and stream characteristics of Cedar Creek Site, Jackson County, Illinois.

Vegetation Category	Width of Vegetation (m) north	south	Stream Channel Characteristics: Width (m)	Depth (m)	Bottom Type	Riffle/Pool Frequency	Man-made Alterations
V	100+	15	9	0.5	mud, silt	continuous pool	powerline clearing

Cave Trapping Sites

(8) Cave Spring Cave Site (Main Entrance)
Hardin County
T12S, R7E, NW/4-SE/4-NW/4-SE/4 Section 23
(Shetlerville 7.5' quadrangle)
Figure 1

The main entrance is an opening in large rubble and measures approximately 1 m by 1.5 m in size. Such a small entrance is easily sealed off with a bat trap and heavy netting. This main entrance to the cave occurs at the southern end

of a large sinkhole located in the center of the SE/4 of Section 23. Water enters this entrance (through some cracks and crevices lower than the cave entrance proper) during periods of heavy rain. As a result, the initial entrance passageway contains a permanent, wall to wall lake. This cave stream exits the cave passageway through a spring resurgence in the NE corner of Section 26.

The cave passageway has suffered severe structural damage as a result of blasting from a surface limestone quarry east of and parallel to the cave's passageway. In addition to this disturbance, water was being pumped from an inundated portion of the quarry up into drill holes in the ceiling of the cave. This water, being pumped at a rate of 1,000,000 gals./day was not only causing additional structural damage to the passageway, but was drastically changing the microclimate of the cave.

(9) Rich's Cave Site
Union County
T11S, R1W, SW/4-SW/4-NW/4-NW/4 Section 27
(Makanda 7.5' quadrangle)
Figure 1

The entrance to Rich's Cave occurs in an exposed rock outcrop at the base of a north-facing slope. The roughly 3 m wide by 4 m high entrance has a stream flowing from it and cascading down a rubble-covered channel. The cave's passageway extends for several hundred feet through the hillside and has a sinkhole opening at its extreme other end (however, it is not possible to enter this opening). Several rooms with high domes create ample areas for bat roosts high above the floor.

Rich's Cave has been effectively protected by the land owner (who lives nearby). The cave is under no obvious or immediate threat.

(10) Ava Cave Site
Jackson County
T8S, R4W, SE/4-SE/4-SE/4-SW/4 Section 4
(Raddle 7.5' quadrangle)
Figure 1

The entrance to Ava Cave occurs in a sinkhole adjacent to a county road and is part of Shawnee National Forest administered lands. The approximately one square meter opening into passageway accepts large amounts of water during heavy rains. As a result, large piles of leaves, sticks and debris are piled near the entrance. Several levels of passageway have formed in this maze-like cave, but could in no way be construed as confusing to explore.

This cave is a very popular site for visitation. Much graffiti and trash occur at the entrance and inside the cave. Surveyors have apparently utilized the entrance as a fixed point from which to survey, because several trees around the entrance had been cleared, or blazed with an axe and spray painted surveyor's orange, making the entrance visible even from the county road.

(11) Toothless Cave (Bat Cave)
Jackson County
Reported: T10S, R3W, SW/4-SE/4-SW/4 Section 26
(Wolf Lake 7.5' quadrangle)
Location not shown

This cave was searched for on 2 October 1985, but no entrance could be found. Whitaker (1975) reported the occurrence of 52 bats in this cave during a 25 February 1974 visit. The location reported by Whitaker (1975) was searched thoroughly, including a large sinkhole to the east of the reported location. Inquiries of local residents provided no clues to the location of the entrance, but one person said he believed that it had collapsed.

The secondary (old) name "Bat Cave" implies usage by large numbers of bats. This cave could be a potentially significant site for bats if its entrance is obscure and hard for people to find. An investigation into the location of this cave and a subsequent visit could prove beneficial to our knowledge of bat caves in southern Illinois.

MATERIALS AND METHODS

Live Capturing and Trapping Bats

Live capturing bats at surface sites was accomplished by utilizing black, monofilament Japanese mist nets. These nets are 38 mm mesh, can be spread to a height of 2.2 m, and range in length from 9.1 m to 18.3 m. Pairs of 9.2 m or 6.2 m high interconnecting poles are used to position nets well above ground level. On such high net sets, two to four mist nets of equal length are stacked vertically, one on top of the other, and suspended between pairs of poles by a rope and pulley system. The top of the uppermost net can be raised to a height of 6.2 m or 9.2 m and all nets can be lowered easily to retrieve bats. Whenever these nets are set over streams, areas are chosen where the trees create a complete natural canopy. The nets are placed over the stream, perpendicular to the banks and immediately behind, or underneath, the canopy to create a netting plane between the water and tree canopy. Often an additional net is placed near water level adjacent to the high net set to completely close off the flyway. The area covered by mist nets ranges from 117.12 square meters to 58.24 square meters, depending upon the length of nets and height of poles that are used. Nets are placed in the capture position at sunset and checked at maximum intervals of fifteen minutes until midnight, and usually later.

Live trapping of bats at cave and mine entrances was accomplished by using a collapsible, highly portable trap similar to the one described by Tidemann and Woodside (1978). This trap measures approximately 1.5 square meters and is constructed of an aluminum frame with strands of monofilament fishing line suspended vertically under tension. When the trap is positioned in entrances and passageways, heavy nylon netting is draped around the edges of the trap and attached to the entrance ceiling, walls and floor. This heavy netting forces the bats to fly into the monofilament strands of the trap which they

cannot perceive with their echolocation. The bats are stopped in flight by the strands and fall harmlessly into a canvas bag from which they are easily removed.

Data recorded for each bat captured included: species, sex, age (adult or immature), reproductive condition, weight, direction and height in the mist net (for surface captures), arriving or departing (for cave and mine captures) and capture time. Bats were captured, examined, and immediately released unharmed at site of capture. Environmental factors, such as sky condition, moon phase, temperature, and wind were used to assess bat activity and capture success. Age was determined by the degree of closure of the phalangeal epiphyses and, to a lesser degree, by tooth wear. Bats were categorized as juvenile by their small overall size and incomplete ossification of the epiphyses.

Reproductive condition of males was determined by size and position of the epididymides. Scrotal bats were characterized by enlarged, or swollen, epididymides in pigmented sheaths dorsolateral to the tail. Enlarged testes usually accompany descended epididymides. Female bats were diagnosed as lactating, or post-lactating, on the basis of teat examination. Pregnant females were examined and their condition diagnosed by gently palpating the fetus through an obviously enlarged abdomen (care must be taken not to mistake a food-distended stomach for a fetus) or by body weights characteristic of pregnancy.

Observations of early foraging activity of bats were attempted at each capture site. These observations provided valuable data on times of initial flight, as well as the location of bats in relation to the tree canopy when they first emerged. Foraging behavior of the bats can be observed in this manner, and can be used to aid in evaluations of capture success and significance of foraging areas. Observed bats are identified to genus (if possible) on the basis of size, flight activity patterns, and subsequent capture.

Bat Banding

Bats were banded with size XCL consecutively numbered, color-coded, celluloid split ring bird bands (A. C. Hughes, England). A single, solid-colored band was placed upon the forearm of the right wing for males and left wing for females. Care was taken in choosing colors that would not be easily confused with bats banded during previous studies conducted in Missouri. Number 9 bands were removed from all groupings of bands (except for Orange) and not used, because they cannot be distinguished from number 6 bands. Likewise, number 99 bands were removed because they are indistinguishable from number 66 bands.

RESULTS

Surface Mist Netting Sites

(1) Wallace Branch Site: Bat Capture Data

This site was mist netted for bats on 18 June 1985. Two bats of different species were captured (Table 8). Several bats were observed flying around the dead trees and over the stream at 2048 hrs. However, the first bat was not captured until 2200 hrs.

Table 8. Bat capture data for Wallace Branch Site, Hardin County, Illinois.

Date	Species	No.	Age	Sex	Rep. Cond.
06-18-85	*Pipistrellus subflavus*	1	A	M	NR
	Eptesicus fuscus	1	A	M	Scr

M=male, F=female, A=adult, J=juvenile
Scr=scrotal, Pg=pregnant, L=lactating, PL=post-lactating, NR=nonreproductive

Climatological factors were characterized by a temperature of 19 degrees C at dusk (2048 hrs.) that dropped to 17 degrees by 2400 hrs. A clear sky and light breezes were characteristic of the netting period. A new moon stage had no noticeable effect on bat activity.

(2) Bay Creek Site: Bat Capture Data

This site was mist netted for bats on 3 June 1985. Six bats representing three species were captured and examined at this netting site (Table 9). One bat was observed flying high above the creek at dusk (2045 hrs.) and three *Pipistrellus subflavus* were captured five minutes later. Two *Eptesicus fuscus* and a *Lasiurus borealis* were captured simultaneously at 2130 hrs.; no bats were captured after that time.

Table 9. Bat capture data for Bay Creek Site, Pope County, Illinois.

Date	Species	No.	Age	Sex	Rep. Cond.
06-03-85	*Pipistrellus subflavus*	1	A	M	Scr
	" "	2	A	F	Pg
	Lasiurus borealis	1	A	F	L
	Eptesicus fuscus	2	A	M	Scr

M=male, F=female, A=adult, J=juvenile
Scr=scrotal, Pg=pregnant, L=lactating, PL=post-lactating, NR=nonreproductive

Climatological factors were characterized by a temperature of 23 degrees C at dusk (2045 hrs.) that dropped to 22 degrees by 2230 hrs. Skies were completely overcast at the onset of netting and heavy rain began at 2230 hrs. A full moon was obscured by clouds and probably would not have interferred with bat activity, but threatening weather may have influenced foraging behavior.

(3) Lusk Creek Site: Bat Capture Data

This site was mist netted for bats on 17 June 1985. Two bats representing two species were captured (Table 10). One bat was observed at dusk (2040 hrs.) as it foraged high above the stream in a circular motion. The first bat captured was a *Lasiurus borealis*, captured at 2105 hrs. as it flew downstream.

Table 10. Bat capture data for Lusk Creek Site, Pope County, Illinois.

Date	Species	No.	Age	Sex	Rep. Cond.
06-17-85	*Lasiurus borealis*	1	A	F	L
	Pipistrellus subflavus	1	A	M	NR

M=male, F=female, A=adult, J=juvenile
Scr=scrotal, Pg=pregnant, L=lactating, PL=post-lactating, NR=nonreproductive

A temperature of 19.5 degrees C was recorded at dusk (2040 hrs.) and had dropped one half degree C by 2400 hrs. Weather conditions were characterized by unusually high humidity and partly cloudy skies. The new moon phase had no noticeable effect on capture success.

(4) Big Grand Pierre Creek: Bat Capture Data

This site was mist netted for bats on 19 June 1985. Seven bats of two species were captured at this site (Table 11). Bats were not observed over the creek prior to dusk. The first bat was captured at 2100 hrs. as it flew downstream. All seven bats captured were nonreproductively active males.

Table 11. Bat capture data for Big Grand Pierre Creek Site, Pope County, Illinois.

Date	Species	No.	Age	Sex	Rep. Cond.
06-19-85	*Lasiurus borealis*	3	A	M	NR
	Pipistrellus subflavus	4	A	M	NR

M=male, F=female, A=adult, J=juvenile
Scr=scrotal, Pg=pregnant, L=lactating, PL=post-lactating, NR=nonreproductive

Climatological conditions included a clear sky and calm winds. A temperature of 16 degrees C at dusk (2048 hrs.) dropped to 13 degrees C by 2330 hrs. A new moon was not visible durig the netting period.

(5) Rock Branch Site: Bat Capture Data

This site was mist netted for bats on 20 June 1985. Two lactating adult female *Lasiurus borealis* were captured at this netting location (Table 12). Several bats were observed flying in circular motions in openings near the creek at dusk (2040 hrs.). The first red bat was captured five minutes later.

Table 12. Bat capture data for Rock Branch Site, Saline County, Illinois.

Date	Species	No.	Age	Sex	Rep. Cond.
06-20-85	*Lasiurus borealis*	2	A	F	L

M=male, F=female, A=adult, J=juvenile
Scr=scrotal, Pg=pregnant, L=lactating, PL=post-lactating, NR=nonreproductive

Climatological conditions included clear skies and calm winds. A temperature of 17 degrees C at dusk (2040 hrs.) had dropped to 16 degrees C by 2200 hrs. A new moon stage was not visible during the netting period.

(6) Cache River Site: Bat Capture Data

This site was mist netted on 9 July 1985. Nine bats representing five species were captured and examined at this site (Table 13). Included in these captures were a juvenile female *Myotis sodalis* and two juvenile male *Myotis grisescens*. A juvenile male *Plecotus rafinesquii* was captured also. Several bats were observed foraging above the river at dusk (2040 hrs.) and the first bat was captured at 2100 hrs.

Table 13. Bat capture data for Cache River Site, Johnson County, Illinois.

Date	Species	No.	Age	Sex	Rep. Cond.
07-09-85	*Myotis sodalis*	1	Juv	F	NR
	Myotis grisescens	2	Juv	M	NR
	Plecotus rafinesquii	1	Juv	M	NR
	Lasiurus borealis	1	A	M	Scr
	" "	1	Juv	M	NR
	Pipistrellus subflavus	1	Juv	M	NR
	" "	1	A	F	L
	" "	1	A	M	NR

M=male, F=female, A=adult, J=juvenile
Scr=scrotal, Pg=pregnant, L=lactating, PL=post-lactating, NR=nonreproductive

Climatological conditions were characterized by partly cloudy skies which became clear during the netting period. Winds were calm and a temperature of 24 degrees C at dusk (2040 hrs.) dropped one half degree by 2400 hrs. A last quarter moon was not visible during the netting period.

(7) Cedar Creek Site: Bat Capture Data

This site was mist netted for bats on 10 July 1985. Eight bats representing five species were captured at this netting site (Table 14). Included in these captures were a nonreproductively active female, a post-lactating adult female and a juvenile male *Myotis sodalis*. Two bats were observed at dusk (2040 hrs.) as they foraged high above the creek. The first bat captured was a reproductively active *Lasiurus borealis*.

Table 14. Bat capture data for Cedar Creek Site, Jackson County, Illinois.

Date	Species	No.	Age	Sex	Rep. Cond.
07-10-85	*Myotis sodalis*	1	A	F	NR
	" "	1	A	F	PL
	" "	1	Juv	M	NR
	Lasiurus borealis	1	A	M	Scr
	" "	1	Juv	F	NR
	Myotis keenii	1	A	F	L
	Eptesicus fuscus	1	A	M	NR
	Lasiurus cinereus	1	Juv	M	NR

M=male, F=female, A=adult, J=juvenile
Scr=scrotal, Pg=pregnant, L=lactating, PL=post-lactating, NR=nonreproductive

Climatological conditions were characterized by clear skies and calm winds. A temperature of 22 degrees C at dusk dropped only one degree by 2345 hrs. A last quarter moon was not visible during the netting period.

Cave Trapping Sites

(8) Cave Spring Cave Site: Bat Capture Data

Bats were captured at the entrance to Cave Spring Cave on two occasions. A total of 22 bats were captured on 1 June 1985 and 26 bats were captured on 8 July 1985 (Table 14). The captures on 1 June included four *Myotis sodalis*, but no *Myotis grisescens*. However, the captures on 8 July included three

Myotis sodalis and 16 *Myotis grisescens*. It is significant to note that only one female bat was captured: a lactating adult *Myotis grisescens*.

Table 15. Bat capture data for Cave Spring Cave Site, Hardin County, Illinois.

Date	Species	No.	Age	Sex	Rep. Cond.
06-01-85	*Myotis sodalis*	4	A	M	NR
	Myotis lucifugus	2	A	M	NR
	Myotis keenii	3	A	M	NR
	Pipistrellus subflavus	1	A	M	Scr.
	" "	9	A	M	NR
	Eptesicus fuscus	3	A	M	Scr
07-08-85	*Myotis sodalis*	3	A	M	NR
	Myotis grisesecens	15	A	M	NR
	" "	1	A	F	L
	Myotis keenii	1	A	M	NR
	Myotis lucifugus	2	A	M	NR
	Pipistrellus subflavus	4	A	M	NR

M=male, F=female, A=adult, J=juvenile
Scr=scrotal, Pg=pregnant, L=lactating, PL=post-lactating, NR=nonreproductive

Climatological conditions on both trap nights were characterized by clear skies. A temperature of 23.5 degrees C on 1 June dropped to 22 degrees C by 2415 hrs. The temperature on 8 July was 27 degrees at dusk (2030 hrs.) and dropped to 24 degrees C by 2335 hrs. A full moon on 1 June was not visible until later in the trapping period. A waning moon phase from the full moon was not visible during the 8 July trapping night.

(9) Rich's Cave Site: Bat Capture Data

The entrance to Rich's Cave was trapped for bats on 1 October 1985. The first bat captured was a *Myotis lucifugus* that emerged from the cave at 1852 hrs. (Table 16). However, the next bats were not captured until 1930 hrs. Thirty-two bats were captured, including two adult male *Myotis sodalis*. Five *Eptesicus fuscus* were not captured, but were observed in a deep torpid state on the ceiling of the cave 12 m from the entrance.

Table 16. Bat capture data for Rich's Cave Site, Union County, Illinois.

Date	Species	No.	Age	Sex	Rep. Cond.
10-01-85	*Myotis sodalis*	1	A	M	Scr
	" "	1	A	M	NR
	Myotis lucifugus	25	A	M	Scr
	" "	1	A	F	NR
	Myotis keenii	1	A	M	Scr
	" "	2	A	F	NR
	Pipistrellus subflavus	1	A	M	Scr
	Eptesicus fuscus	5	(observed only)		

M=male, F=female, A=adult, J=juvenile
Scr=scrotal, Pg=pregnant, L=lactating, PL=post-lactating, NR=nonreproductive

Climatological conditions early in the trapping night included an overcast sky and a temperature of 11.5 degrees C at dusk (1852 hrs.). However, the sky became clear during the course of trapping and the temperature dropped to 4 degrees C by 2130 hrs. A waning moon phase from a full moon was visible later in the netting period.

(10) Ava Cave Site: Bat Capture Data

The sinkhole entrance to Ava Cave was trapped on 2 October 1985. Three adult male *Pipistrellus subflavus* were captured (Table 17). However, there was a strong indication that one bat was captured twice, since the weights for two captures were identical.

Table 17. Bat capture data for Ava Cave Site, Jackson County, Illinois.

Date	Species	No.	Age	Sex	Rep. Cond.
10-02-85	*Pipistrellus subflavus*	3	A	M	Scr

M=male, F=female, A=adult, J=juvenile
Scr=scrotal, Pg=pregnant, L=lactating, PL=post-lactating, NR=nonreproductive

Climatological conditions were characterized by clear skies and calm winds. The temperature was 10 degrees C at 1910 hrs. when the first bat was captured and dropped to 8 degrees C by 2000 hrs. A waning moon phase from a full moon was not visible until later in the netting period.

Bat Banding Data

A total of 13 *Myotis sodalis* and 18 *Myotis grisescens* were banded during this study. Bands were placed on an additional 19 bats captured at Cave Spring Cave. Bats were banded as part of long-term ecological investigations in Illinois. Banding data are submitted to the National Fish and Wildlife Laboratory, Fish and Wildlife Service, National Museum of Natural History (USDI, Washington, D. C.), Indiana/Gray Bat Recovery Team, and to cooperators in this project.

DISCUSSION

The primary objective of this study was to conduct preliminary investigations into the occurrence, distribution and status of *Myotis sodalis* and *Myotis grisescens* populations within the Shawnee National Forest purchase unit boundaries. The original project proposal (submitted and accepted 3 April 1985) had indicated that only four surface stream sites and two cave or mine sites would be investigasted. However, seven stream sites and three cave sites were investigated during this preliminary study. *Myotis sodalis* were captured at two stream sites and two cave sites. *Myotis grisescens* were captured at one stream site and one cave site. These preliminary findings provide conclusive evidence that these two species presently utilize habitats within the Shawnee National Forest.

This discussion will provide a historical perspective of information collected by previous investigators. Recent data, collected during the course of this study, will be combined with these historical records as an indication of the status of Indiana and gray bat populations on the Shawnee National Forest. Previous records are, for the most part, scattered and contain limited information, particularly on age and sex criteria.

Myotis grisescens - Gray bat

The gray bat is a highly migratory, social species which establishes nursery colonies in caves during summer and hibernates in different caves during the winter. The range of the species is closely associated with major cave regions of the eastern United States, extending from eastern Tennessee and Kentucky through extreme southern Indiana and southern Illinois. This range includes practically all of Missouri, southeast Kansas, northeast Oklahoma, and northern Arkansas. A southern extension of the range includes most of Alabama as far south as northwest Florida and portions of northwest Georgia and northeast Mississippi (Hall 1981).

Loyalty to hibernacula and maternity caves has been reported to be strong (LaVal and LaVal 1980; Myers 1964; Tuttle 1976). Gray bats establish nursery colonies, sometimes numbering thousands of individuals, from mid-April to September in caves meeting very narrow microclimate requirements. Copulation occurs during the autumn; sperm is stored by females during hibernation (delayed fertilization). In Missouri, colonies of pregnant females began to form in early April and foraged over Ozark streams or lakes in the vicinity of the cave. Males and non-reproductive females form "bachelor" colonies in other caves (usually nearby) and are virtually absent from maternity roosts. A single young is born during June and is capable of leaving the cave by late July (LaVal and LaVal 1980).

Myotis grisescens forage almost exclusively over rivers, streams, and lakes within 2 km of their cave (LaVal *et al.* 1977; LaVal and LaVal 1980; Tuttle 1976). In Missouri, aquatic insects are predominant sources of food when they are available. Beetles, particularly species most abundant in forested cliffs along rivers, become an important food source in late summer (Schwartz and Schwartz 1981).

By late September gray bats begin arriving at hibernacula (those few caves meeting very narrow microclimate requirements). Gray bats choose hibernation sites where the air temperature is 7 to 10 degrees C (45 to 50 degrees F) (Barbour and Davis 1969). Both sexes congregate in the hibernacula after swarming behavior (copulation occurs primarily during swarming behavior). In Missouri, females congregated in increasing numbers at major transient caves during September and most had moved to more southern hibernacula by the end of the month. Males remained in the summer colony area during October, gradually moving south to hibernacula by early November (LaVal and LaVal 1980). This delayed migration increases the potential for males to copulate with females as they arrive at transient caves and hibernacula.

Gray bats are especially vulnerable to human-induced mortality, primarily juvenile death due to disturbance at nursery caves. When female gray bats with young are frightened by cave visitors they often panic, dropping their young to the cave floor or guano pile. Once an immature, non-volant bat has fallen to the floor, its chances of survival are practically nonexistent. Other factors contributing to the decline of the species include natural disasters (i.e. flooding, freezing, and collapse of mines or caves), disturbance at hibernacula, stream channelization, deforestation, and pesticide poisoning (Clark *et al.* 1978, 1983; Tuttle 1979).

Because *Myotis grisescens* is completely dependent upon caves, it never has been well known in Illinois. The species once was common in a cave near Rosiclare in Hardin County (Cory 1912; Whitaker 1975). Movements of this colony (reported as a nursery colony) were studied by Hall and Wilson (1966). Although their sample size was small, they recaptured one banded bat at Coach-James Cave (a large hibernaculum for gray bats) in Kentucky. The occurrence of gray bats elsewhere in Illinois is sporadic at best, but they have been found using a few small caves and mines as transient sites in Pike and Adams counties (Kerr 1973; Skaggs 1973; Thom 1981; unpublished data, Illinois Department of Conservation). Movements of *Myotis grisescens* from a

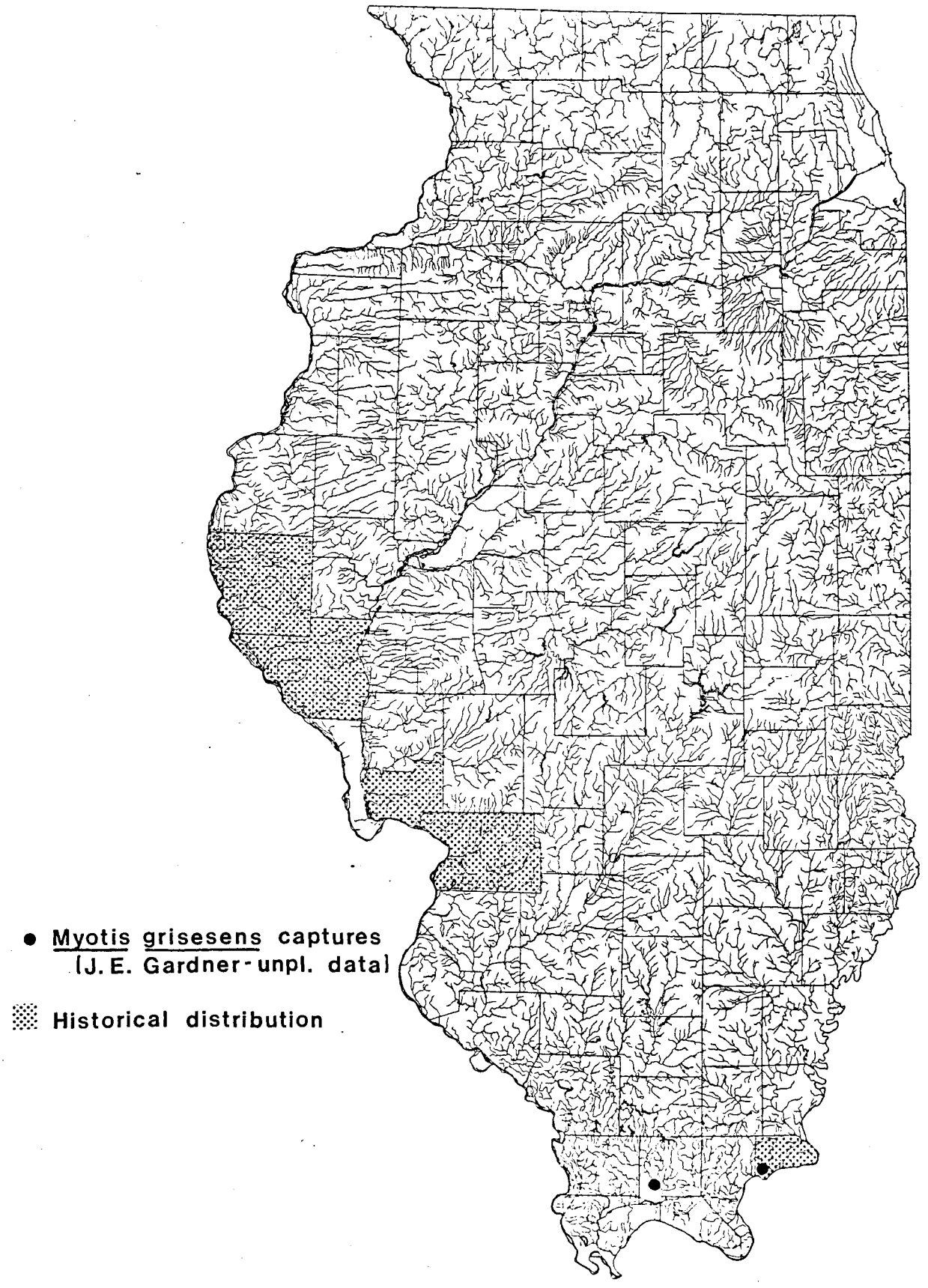

Figure 2. Historical distribution of Myotis grisescens in Illinois, including unpublished records of occurrence collected during investigations on the Shawnee National Forest.

hibernaculum in Shannon County, Missouri to a transient cave in Pike County have been documented (Kerr 1973). Other records are of individuals taken from a cave and a sewer in Jersey and Madison counties, respectively (Thom 1981). There are no known hibernacula for *Myotis grisescens* in Illinois, although solitary hibernating gray bats may be infrequently encountered in caves or mines (Figure 2).

Studies of *Myotis grisescens* populations in Alabama and Tennessee showed that numbers had decreased by 47% by the year 1970 and decreased by an additional 54% during the next six years (Tuttle 1979). Due to relatively great longevity, population levels may appear to remain stable for a few years, even though young may not have been sucessfully reared during that time (Tuttle 1979). Populations in Missouri may have been reduced 72% to 81% over the past 50 years. Of 27 known maternity caves in Missouri, at least 16 have been abandoned (LaVal and LaVal 1980). Such a high rate of decline is evident for one Illinois population of *Myotis grisescens* that was reduced by at least 80% over 28 years (Hall and Wilson 1966).

Myotis sodalis - Indiana bat

Myotis sodalis is a highly migratory species, widely distributed in summer, but more concentrated in caves during winter hibernation. The range of the species includes most of the eastern United States, being closely associated with major cave regions and areas north of these regions (Hall 1981). Approximately 66% of the known population (or about 350,000 bats) hibernate in a few caves and one abandoned mine in Missouri (LaVal and LaVal 1980; Schwartz and Schwartz 1981). The remaining one third of the population hibernates primarily in one cave in Indiana and one in Kentucky.

Homing of *Myotis sodalis* to their hibernacula is well developed (Hassell and Harvey 1965). As many as 80% of banded bats have returned to the hibernaculum from which they were banded (Cope *et al.* 1974). Although continuous waterways are probably used as avenues of travel and homing for *Myotis sodalis* (Hall 1962), other studies have shown they are not entirely necessary for successful homing (Hassell and Harvey 1965). A very high recapture rate (64.4%) of *Myotis sodalis* banded at their hibernaculum and released north of their cave suggests familiarity with the area (Hassell and Harvey 1965). If the species exhibits such a strong homing instinct for hibernacula, it seems reasonable to assume that loyalties to summer maternity areas exist as well. In fact, recaptures of banded *Myotis sodalis* during several subsequent summers were reported for a summer nursery population in Indiana (Humphrey *et al.* 1977).

Little information is available concerning *Myotis sodalis'* summer distribution within its range. Recaptures of banded bats have documented summer migrations northwest from Kentucky hibernacula into Indiana, Ohio and Michigan (Barbour and Davis 1969). Banded female and juvenile Indiana bats from Missouri hibernacula were recaptured throughout northern Missouri and one record is from Iowa (LaVal and LaVal 1980; J. B. Bowles, pers. comm.). Records of *Myotis sodalis* in extreme southern and west-central Illinois, indicate additional movements southeast, east and northeast from Missouri hibernacula (Brack 1979; Thom 1981; Gardner and Taft 1983, 1984). Additionally, Indiana

bats hibernating in the only known existing hibernaculum in north-central Illinois should characteristically migrate into northern Illinois and possibly as far north as Wisconsin.

Female *Myotis sodalis* are first to leave the hibernacula in early spring, followed by juveniles of both sexes, and finally by adult males. Most bats are gone by the end of April (LaVal and LaVal 1980). Large numbers of male Indiana bats apparently remain in the Missouri Ozarks near their hibernacula (LaVal and LaVal 1980). Adult mortality is undoubtedly high during migrations in late March and early April as a result of diminished fat reserves and low insect prey supplies (U. S. Dept. Interior 1983).

Very little information concerning *Myotis sodalis*' summer habitat requirements is known. However, floodplains and their associated riparian vegetation are considered the most valuable land in the summer range of the species (Humphrey *et al.* 1977; USDI 1983). Until recently, summer records of *Myotis sodalis* were sparse and scattered. Immature males have been captured from beneath a concrete bridge and beneath the bark of an old, dead tree (Mumford and Cope 1958). [An immature *Myotis sodalis* reported from a house by Mumford and Cope (1958) was incorrectly identified (Humphrey *et al.* 1977).] In Illinois, Indiana and Missouri pregnant and lactating female and juvenile *Myotis sodalis* have been reported flying along woodlot borders and over lakes (Mumford and Cope 1958; Mumford and Calvert 1960; Easterla and Watkins 1969).

Recent studies have contributed greatly needed data on summer habitat requirements of *Myotis sodalis*. LaVal and LaVal (1980) reported capturing a few lactating females and juveniles most often over streams in northern Missouri. The streams were characterized by thin strips of riparian vegetation with adjacent croplands. Adult females and juveniles were captured over and near the Kankakee River in extreme northwest Indiana (Brack and Holmes 1982). Summer populations in other areas of Indiana have been well documented (Cope *et al.* 1974; Humphrey *et al.* 1977).

In Illinois, *Myotis sodalis* records have been reported from throughout the state, but in most cases probably more closely illustrate individual records and areas that have been selectively sampled rather than meaningful population structures (Figure 3). Juvenile and reproductively active adult female *Myotis sodalis* have been reported from Jackson, Perry, Pike, Union and Wabash/Edwards counties in Illinois (Brack 1979; Sparling *et al.* 1979; Gardner and Gardner 1980; Kessler and Turner 1980; Kirkpatrick 1980; Dunstan and Warnock 1981; Gardner and Taft 1984). Additional Illinois records for the Indiana bat include Christian, Cook, Hardin, McDonough and Morgan counties (Dunstan and Warnock 1981; Thom 1981; Gardner and Taft 1983, 1984; Unpublished records, Illinois Department of Conservation). LaSalle County records represent one of few remaining Illinois hibernacula for *Myotis sodalis*. One cave in Monroe County may be more significant to hibernating Indiana bats than was previously believed. In addition, a Madison County record is from a cave and a JoDaviess County record is a winter record over 30 years old. Pearson and Barr (1962) collected one *Myotis sodalis* from an unspecified cave or abandoned silica mine in either Union, Alexander or Pulaski county.

Only in Indiana have any maternity roosts of *Myotis sodalis* been discovered. The first reported nursery colony was discovered when a dead American elm (*Ulmus americana*) was destroyed by a bulldozer (Cope *et al.* 1974).

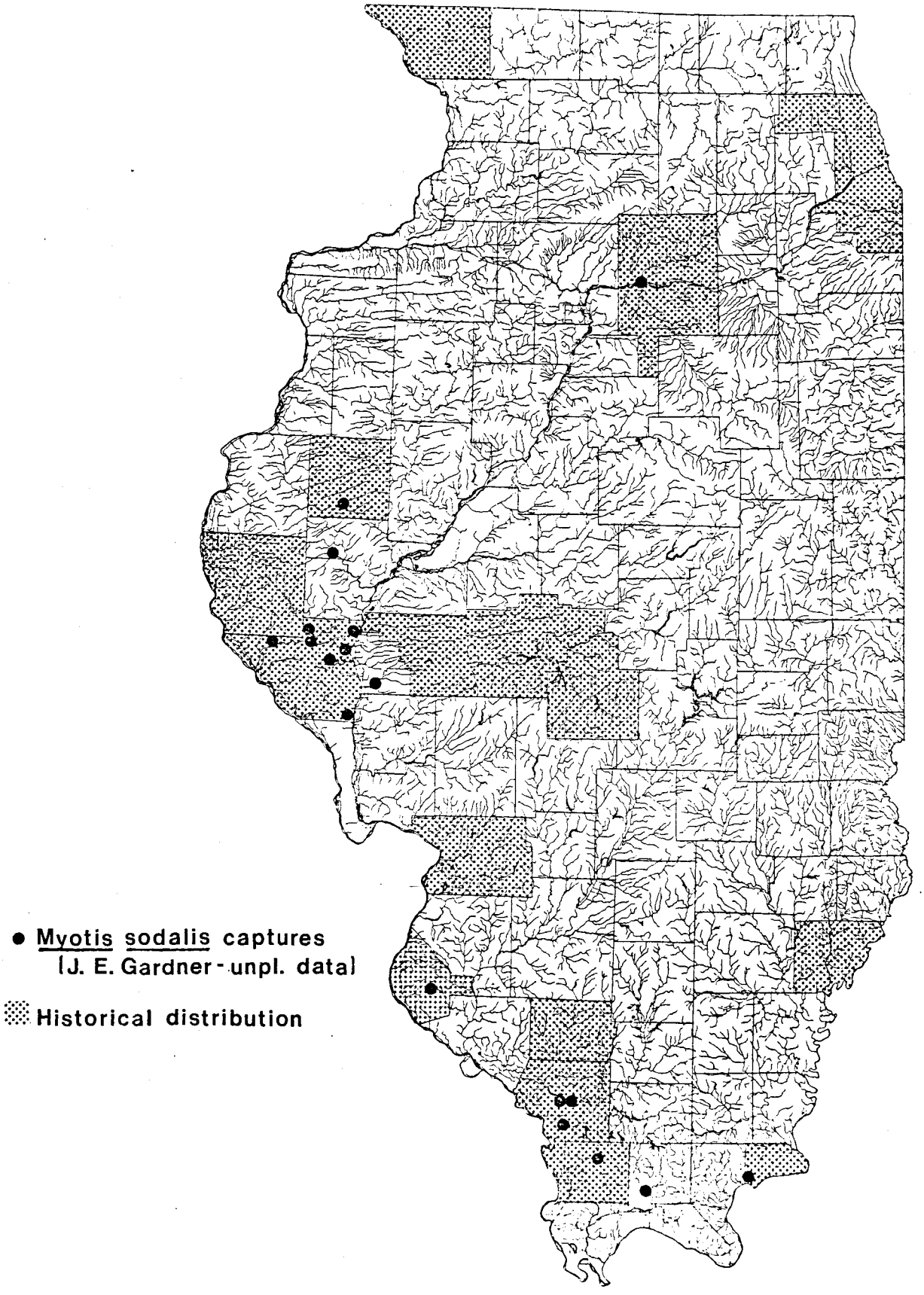

Figure 3. Historical distribution of Myotis sodalis in Illinois, including unpublished records of occurrence from Gardner and Gardner 1980, Gardner and Taft 1983, and Gardner and Taft 1984.

Fortunately, the colony re-established itself in the area in a dead bitternut hickory (*Carya cardiformis*), but was not rediscovered until a few years later (Humphrey *et al.* 1977). The authors also reported that the colony was utilizing the naturally exfoliating bark of a living shagbark hickory (*Carya ovata*) as an alternative roosting place. Another occurrence of Indiana bats in a shagbark hickory was reported by Whitaker (pers. comm.). Eleven adult female Indiana bats were killed when this tree was cut down on 8 September 1984 (Knox County, Indiana). Whitaker further reported that the tree was in a rather open, pastured woodlot that contained a number of dead trees. It was most surprising that a couple of ponds were nearby, but no streams.

Observations and ecological studies of the maternity population in Indiana (Belwood 1979; Cope *et al.* 1974; Humphrey *et al.* 1977; Richter *et al.* 1976) indicated that the foraging habitat of approximately 25 females and 23 young was confined to the foliage of riparian floodplain trees. They found that bats flew within an air space from 2 to 30m high along a linear strip of creek vegetation 0.82 km in length. The foraging area was found to include 1.47 ha in early summer, but expanded to 4.54 ha in mid-summer. The trees along the streambank overhung the stream to form a closed canopy. Other nearby creeks lacking closed canopies were not used for foraging (Humphrey *et al.* 1977).

The study by Belwood (1979) dealt with the feeding ecology of an Indiana bat community, with emphasis on the Indiana bat. Studying the maternity colony first reported by Cope *et al.* (1974), she found that on a nightly basis the majority of insect activity (analyzed in three-hour intervals) occurred during the first three hours after sunset, regardless of habitat or date. Diptera were the most frequently captured insects and accounted for over 75% of the total catch in each habitat. The majority of Diptera consumed were from families that form large mating aggregations above or near the water. Prey selection varied seasonally with respect to the reproductive condition of the animals. During pregnancy, Diptera and Lepidoptera were preyed upon most frequently. Together with Tricoptera, these accounted for almost 90% of the diet. During lactation, Lepidoptera were the dominant prey and accounted for approximately 70% of the food items. Although never very important in the diet, more beetles were eaten during late summer than during any earlier period.

Cope *et al.* (1978) reported netting bats from at least two maternity populations of *Myotis sodalis* along the Big Blue River in east-central Indiana. They reported a foraging area of 1.2km in length for one colony, of which foraging bats flew over the wooded river or around the riverside trees. They reported colony sizes of 100 and 91 individuals, respectively, including adult female and juvenile bats (colony size was estimated on the basis of netting success). Both colonies utilized an area of the river that Cope *et al.* (1978) classified as excellent habitat (more than 30m of woody vegetation on both sides of the stream).

Adult female *Myotis sodalis* probably give birth to a single young during late June, having stored sperm during hibernation (delayed fertilization). Some mating occurs as bats leave hibernation in late April. Presumably, young female Indiana bats mate during their first autumn and have offspring the following year, whereas males do not mature until the following year. The young are capable of flight within a month of birth. Mumford and Cope (1958)

reported that an immature taken from beneath a concrete bridge in Indiana in late July appeared barely able to fly. Bowles (1981) has taken volant young as early as the first week of July in Iowa. Cope *et al.* (1974) reported netting the first immature *Myotis sodalis* in Indiana on 18 July. Gardner and Gardner (1980) captured volant immature Indiana bats as early as 14 July in Pike County, Illinois.

Summer habitat and foraging behavior of maternity female and juvenile *Myotis sodalis* differs significantly from that reported for summer populations of males in Missouri. LaVal *et al.* (1977) observed the largest percentage of male Indiana bats flew cross-country and upstream toward narrower, more densely wooded areas. They further reported *Myotis sodalis* foraging over and among tree canopies in dense forest, mostly on hillsides and ridgetops. None were observed utilizing streams or pastures for foraging habitat. However, LaVal *et al.* (1977) further stated that this foraging activity was probably the result of competitive displacement by the gray bat (*Myotis grisescens*). Bowles (1981) has captured foraging Indiana bats in upland sites in Iowa.

Trapping *Myotis sodalis* at one Missouri hibernaculum indicated that females began to reappear in small numbers in early August, but numbers peaked in late August (LaVal and LaVal 1980). They further stated that the largest numbers captured during any one night at this major hibernaculum was during late September (at a rate of 2,000 per hour). Females and males were captured returning to the hibernaculum through the first week of November (LaVal and LaVal 1980). Nocturnal swarming behavior begins upon arrival at hibernacula. Swarming continues for several weeks, resulting in mating and the accumulation of fat reserves for hibernation. Males generally remain active for a longer period of time during swarming than females (LaVal and LaVal 1980).

The highly gregarious habits of *Myotis sodalis* during hibernation have contributed greatly to its vulnerability. Flooding (Hall 1962), ceiling collapses (Hall 1962; Brady 1982) and freezing (Humphrey 1978) are all natural disasters responsible for population declines. However, the single most serious cause of decline in *Myotis sodalis* is human disturbance and vandalism in the hibernacula (USDI 1983). Humphrey (1978) reported that Indiana bat populations have declined nationwide 28% in numbers between 1960 and 1975, with the most drastic reduction (by as much as 75%) in Kentucky. He also reported that Illinois winter populations of Indiana bats have been reduced by 42.8% during the same time period.

Other factors contributing to the decline of the species include stream channelization, deforestation and pesticide poisoning. Conlin (1976) reported that 29.7% of the interior streams (or 5,566 km) in Illinois had been channelized by 1976. Deforestation for agricultural practices, road construction, urban expansion, and a host of "progress" related developments all adversely affect the continued existence of *Myotis sodalis*. Pesticide induced mortality of insectivorous bats has been well documented (Mohr 1972; Geluso *et al.* 1976; Clark *et al.* 1983) and has possibly contributed to declining populations of *Myotis sodalis*. There are many unanswered questions about the possible impact of water quality deterioration and food availability which may have even more adverse impacts on *Myotis sodalis* populations.

Cache River Site (Boss Island): Johnson County

The 9 July capture of a single juvenile female *Myotis sodalis* immediately after dusk (2100 hrs.) is not definitive evidence for the presence of a maternity colony within the study area. If a maternity colony of Indiana bats were nearby, it seems resonable to expect captures of adult females and more than one volant juvenile. However, six of nine bats (67%) captured that night were juveniles of four other species. The only adult bats captured were *Lasiurus borealis* and *Pipistrellus subflavus*. In comparison, three *Myotis sodalis* (a nonreproductive adult female, a post-lactating adult female and a juvenile male) were captured in mist nets set in a similar habitat in Jackson County the following night. Taking into account the biases associated with capturing bats by mist netting techniques, it is actually likely that a maternity colony of Indiana bats was located near the netting site. Habitats along the Cache River obviously require additional investigation in order to assess their suitability as *Myotis sodalis* summer maternity sites.

It is very significant that two nonreproductive juvenile male *Myotis grisescens* were captured at this site during the 9 July netting night. Since *Myotis grisescens* reportedly do not begin migration to their hibernacula until late September, these two males must have been born in a nearby cave. The nearest known cave (unnamed cave in sandstone) is approximately 4 km east of the netting site and other caves (in limestone) are reported in the Cave Creek valley 1 km east of the unnamed cave. The captures of these juvenile *Myotis grisescens* over the Cache River represent the first records for this species from a surface habitat in southern Illinois. Furthermore, it is the first recorded occurrence of simultaneous captures of *Myotis sodalis* and *Myotis grisescens* from a surface habitat in Illinois. These preliminary data obviously indicate a need to determine the status of gray bat summer habitat within the Shawnee National Forest boundaries.

Cedar Creek Site: Jackson County

The 10 July capture of three *Myotis sodalis* in mist nets set over Cedar Creek strongly indicates the occurrence of a nearby maternity colony. Indiana bats reportedly begin foraging in the vicinity of their diurnal roost when they first emerge. Several bats (unidentified species) were observed foraging high above the creek at dusk. A nonreproductive adult female was captured 50 minutes after dusk (2040 hrs.), but only 15 minutes after the first bat was captured. A post-lactating adult female was captured 15 minutes after the first female, but the juvenile male was not captured until 120 minutes later. The juvenile bat was small (6.6 grams) and had apparently only recently became volant.

Potential roost trees were examined in the area, but no evidence of usage by bats was determined. There was an obvious absence of trees exhibiting a high potential as roost structures (defined as trees having 25% or more of the main trunk and limbs with loose and peeling bark). It is likely that the maternity site (either a dead, dying or living tree) was located outside the study area or was not adjacent to the stream as expected. In any case, this site should receive the highest priority for further studies to determine the properties that make it suitable to *Myotis sodalis* for maternity habitat.

Cave Spring Cave: Hardin County

The first records of *Myotis sodalis* in Hardin County, Illinois appear to be those of Miller and Allen (1928), who reported ten specimens from Rosiclare. Cory (1912) and Miller and Allen (1928) reported specimens of *Myotis grisescens* from the same locality. It is assumed that all these specimens came from Cave Spring Cave, the only suitable cave site for these species near Rosiclare.

Necker and Hatfield (1941), in their accounts of Illinois mammals, mention specimens in the Field Museum of Natural History from Rosiclare, first reported by Cory (1912) and Miller and Allen (1928). Although Smith and Parmalee (1954) presented new distribution records of bats in Illinois, they provided no new data on Cave Spring Cave bat populations.

Several specimens of *Myotis grisescens* were collected from Cave Spring Cave on 6 August 1950 (Whitaker and Winter 1977) and were deposited in the University of Illinois mammal collection. Three additional specimens of *Myotis grisescens* were collected from the cave in 1955 and can be found in the Southern Illinois University collection of mammals. W. H. Davis banded 80 *Myotis sodalis* from Cave Spring Cave on 29 December 1953. Four male and four female *Myotis sodalis* were collected on 21 December 1954 from two groups of 10 to 15 bats (many of them banded) which were jammed into crevices (Layne 1958; Whitaker 1975). Layne (1958) reported a cluster of about 20 bats in the same position in the cave on his return visit of 12 March 1955.

The next documented investigation into the bat fauna of Cave Spring Cave was by Hall (1962); he found no *Myotis sodalis* on a winter visit in 1957. However, he found two Indiana bats during a winter 1958 visit. Hall and Wilson (1966) included Cave Spring Cave in their banding studies of summer *Myotis grisescens* colonies; they reported a population of 10,000 bats between 1958 and 1961. Furthermore, they reported this population as a maternity colony, but only two females were banded out of a total of five bats captured (they did not report the age class of the male bats). One of these males banded at Cave Spring Cave was recaptured in Coach-James Cave, Edmonson County, Kentucky during winter.

Cave Spring Cave was searched for bats by Whitaker (1975) on 8 March 1974, when he entered the cave as far as the lake. He encountered only *Pipistrellus subflavus* on this date and on 28 August during a second 1974 visit. While conducting mist netting at the cave entrance during his 28 August visit, he captured 80 *Myotis grisescens* (38 females, 41 males and one undetermined). He also reported an estimated colony size of 1000-2000 bats inside the cave at that time. However, Whitaker and Winter (1977) reported that these bats bats formed a compact mass about 1.5 ft. by 5 ft. in area. If the accepted estimate of 1828 bats/m^2 (Tuttle 1975) applies to the packing behavior of Cave Spring Cave bats, the observed cluster of bats occupying 7.5 square feet would number 1371 individuals (1 m^2 = 10 ft^2). It is unfortunate that age class information (adult or immature) was not reported for the capture of the 80 bats. Captures of immature volant males and females in late August would more strongly support usage of the cave as a maternity site. A 4 December 1974 visit to the cave by Whitaker (Whitaker and Winter 1977) provided no additional data on either Indiana or gray bats.

Cave Spring Cave was visited on 12 December 1981, when investigators found 25-30 *Myotis sodalis* within the cave. On 26 March 1982 the cave was revisited and four *Myotis sodalis* and one female *Myotis grisescens* were observed. In addition, fresh guano from the previous summer was measured (Illinois Department of Conservation, unpublished data).

On 3 July 1982 the entrance was netted by C. Mahan *et al.* (Illinois Department of Conservation), resulting in the capture of 10 *Myotis grisescens*. The cave was investigated on 21 August 1982 and an estimated 1000-2000 gray bats were encountered in a cluster in the cave. The cave was revisited the following day and an area of 0.42 square meters (0.6 m by 0.7 m) were measured; the estimated number of bats would be 768.

Cave Spring Cave was visited on 21 March 1985 to investigate the possible occurrence of bats (J. D. Garner, pers. comm.). During that visit, the investigators discovered severe structural damage to the cave. This damage was the result of blasting associated with normal operations of the adjacent limestone quarry. During a subsequent visit on 1 June 1985, it was discovered that water was being pumped out of a flooded area of the quarry and unto four drill holes in the cave ceiling. This water was being pumped at a rate of 1,000,000 gallons/day. Exploration into the cave's passageway revealed that this water had caused additional damage to the cave's structure. In addition, the temperature had been greatly elevated by the introduction of the warmer surface water and "fog" filled the passageway.

Bats were trapped at the entrance to Cave Spring Cave on 1 June 1985. Four male *Myotis sodalis* were captured. Although four other species were captured, no *Myotis grisescens* were captured. However, the cave was trapped again on 8 July 1985, resulting in the capture of 16 *Myotis grisescens* and 3 *Myotis sodalis*. Among these captures was a single lactating female gray bat. If Cave Spring Cave was utilized as a maternity site, female bats should have dominated the captures.

These recent data strongly suggest that Cave Spring Cave is presently utilized as a bachelor and transient site by *Myotis grisescens*. The largest numbers of gray bats have been reported from Cave Spring Cave later in the summer (late August), a time when males begin southern migrations and swarming behavior. The absence of significant numbers of females reported from the cave indicates that use of Cave Spring Cave as a maternity site is highly unlikely. Additionally, recent disturbance resulting from water pumped into the cave and blasting in the quarry has evidently made the cave microclimate unsuitable for maternity use and possibly for further use by large numbers of males.

The largest numbers of *Myotis sodalis* historically reported from the cave was on 29 December 1953 (Whitaker 1975). Since that time, only scant numbers of Indiana bats have been observed there and only during winter or very early spring. Recent captures of *Myotis sodalis* during June and July indicate a slight utilization of the cave by males. Use of a cave in summer by small numbers of male Indiana bats is not unexpected and has been previously reported for the species (LaVal and LaVal 1980). Small numbers of Indiana bats may still utilize Cave Spring Cave as a hibernaculum, but only if the pumping of water and blasting has not significantly altered the suitability of the cave's microclimate.

In order to more clearly illustrate previous investigations into Cave Spring Cave and to gain a better understanding of species populations and patterns of use a summary is provided (Table 18).

Rich's Cave: Union County

Investigations into the utilization of Rich's Cave by bats have been limited. Layne (1958) reported *Pipistrellus subflavus*, *Myotis austroriparius*, *Myotis lucifugus* and *Eptesicus fuscus* during his 5 February 1955 visit. He also apparently visited the cave on 14 November 1954, but encountered only a single *Myotis lucifugus* [Layne's field notes, in Whitaker (1975)]. The cave was visited on 26 February 1974 and again on 5 December 1974 by Whitaker, resulting in the observation of *Myotis lucifugus*, *Pipistrellus subflavus*, *Myotis austroriparius* and *Eptesicus fuscus*. Whitaker (1975) mist netted the entrance on 29 August 1974 and reported capturing *Myotis keenii* in addition to the species mentioned above. The entire passageway was investigated by C. Mahan (Illinois Department of Conservation) on 25 March 1982, at which time she observed 25 *Myotis lucifugus*.

The capture of two adult male *Myotis sodalis* in the cave entrance on 1 October 1985 is a strong indication that Rich's Cave is utilized as a transient site by migrating bats. Although small numbers of bats hibernate in the cave, it is not suitable as a hibernaculum for large numbers of Indiana bats. The cave evidently receives light utilization during the summer, probably from male bats.

Ava Cave: Jackson County

Ava Cave has apparently never been important to bats. Whitaker (1975) reported observing 11 bats there during his 25 February 1974 visit. Three male *Pipistrellus subflavus* were captured at the entrance by trapping on 2 October 1985. These data, combined with the fact that Ava Cave is heavily visited and vandalized, suggest that the cave is not significanly utilized by bats of any species.

Table 18. Summary of historical data on captures and observations of *Myotis grisescens* and *Myotis sodalis* at Cave Spring Cave, Hardin County, Illinois.

DATE	NUMBER *M. sodalis*	NUMBER *M. grisescens*	SOURCE
prior to 1928	unknown	unknown	Cory 1912; Miller and Allen 1928
6 August 1950	0	(several?)	Univ. of Illinois collection Whitaker and Winter (1977)
28 October 1953	0	2	Illinois Natural History Survey collection
29 December 1953	*80	0	Whitaker 1975
21 December 1954	10-15	0	Layne 1958; Whitaker 1975
12 March 1955	20	0	Layne 1958
winter 1957	0	0	Hall 1962
winter 1958	2	0	"
summers 1958-1961	0	10,000	Hall and Wilson 1966
8 March 1974	0	0	Whitaker 1975
28 August 1974	0	1000-2000 (80 captured)	"
4 December 1974	0	0	Whitaker and Winter 1977
12 December 1981	25-30	0	Illinois Department of Conservation
26 March 1982	4	1(female)	"
3 July 1982	0	10	"
21 August 1982	0	1000-2000	"
22 August 1982	0	768(estimate)	"
21 March 1985	0	0	"
1 June 1985	*4	0	Present study
8 July 1985	*3	*16(1 female)	"

*=Banding study

Habitat Evaluation Proceedures for *Myotis sodalis*

Federal agencies are required by the Endangered Species Act of 1973, as amended, to conduct a biological inventory for the purpose of identifying federally listed threatened and endangered species likely to be affected by their activities (ie. site development, construction, management). This is a difficult task since inventories of threatened and endangered species usually require lengthy field examinations which often end before satisfactory results can be obtained. Therefore, evaluation procedures have been developed for use in the field which measure the quality of habitat for a particular species (Schumberger and Farmer 1978). Models have been develped for wildlife species such as white-tailed deer (*Odocoileus virginianus*) and wild turkey (*Meleagris gallopavo*) (Urich *et al.* 1984). However, no accepted models have been created for endangered and threatened species.

Habitat evaluation proceedures (HEP) are designed to describe life requisites (reproductive sites, food requirements and cover) and define, as habitat characteristics, the plant species composition and structure comprising the life requisites for each habitat type. These evaluations are not difficult for animals whose life history requisites have long been studied and are well known, but becomes exceedingly frustrating when applying models to animals for which information on habitat suitability is incomplete. The Indiana bat is a good example of a species for which we do not have sufficient data on life requisites to construct an adequate model.

Suggested guidelines for evaluating the suitability of riparian habitats as maternity sites for Indiana bats were developed by Joseph A. Janecek (ret., U. S. Fish and Wildlife Service, Marion, Illinois). This model was intended to evaluate a unit of riparian habitat for its suitability in meeting the life requisites of female and juvenile Indiana bats during the summer reproductive season. Habitat use information for the Indiana bat was synthesized into scaled values to produce a Habitat Suitability Index (HSI). These values range from 0.0 (completely unsuitable habitat) through 1.0 (optimal habitat). Such a procedure is based on the limiting factor concept and assumes that the HSI is equal to the lowest life requisite value for the species.

This type of modeling allows for a large margin of subjective interpretation on the part of the evaluator. Additionally, the HEP appraisal guidelines developed from the model must be compared to estimates of animal abundance to ensure that they produce reasonable projections of habitat quality. This type of model testing is exceedingly difficult for *Myotis sodalis*, primarily due to limited and biased sampling techniques. The effectiveness of live capturing bats by mist netting is highly variable and biased by a number of factors. Other methods for sampling populations of bats involve the use of electronic bat detectors. However, the ecolocation signals of *Myotis sodalis* are of such low intensity that they are not detected easily.

The HEP model for *Myotis sodalis* has been field tested at twelve mist netting sites in Illinois. Two of these sites were on Shawnee National Forest managed lands. Definite problems emerged concerning the evaluation criteria used to measure life requisite values. For example, the habitat suitability index (HSI) for the Cedar Creek, Jackson County, site was very low (0.0016).

However, a post-lactating adult female, a non-reproductive adult female and a juvenile male *Myotis sodalis* were captured within the evaluation area. A Schuyler County site and a Scott County site had HSI values of 0.0025 and 0.0284, respectively, but juvenile Indiana bats were captured at both sites and a lactating female was captured at the Schuyler County site. In contrast, one site in Shelby County had an HSI of 0.37 and was evaluated as potentially good Indiana bat habitat. This seemingly suitable habitat was sampled and six bats representing two tree species were captured (5 *Lasiurus borealis*; 1 *Nycticieus humeralis*).

There is a problem with life requisite value (LRV) number nine which numerically ranks the number and size of dead trees with loose and peeling bark. Since HSI values are based on the limiting factor concept, it is reasonable to assume that a lack of potential maternity trees in a riparian habitat is a factor limiting that habitat's suitability for providing reproductive cover. This assumption is biased because it is based on limited information concerning maternity site requirements for Indiana bats. Indiana bats have been reported to utilize dead and living trees during summer, but no preferences have been demonstrated. One tree utilized by Indiana bats occurred in a riparian habitat, but another occurred in an open grazed pasture with only a pond nearby. Further studies are needed to determine the maternity tree (site) requirements of *Myotis sodalis* before its potential habitat value can be accurately evaluated.

Recommendations

(1) The Cedar Creek Site, Jackson County and the Cache River Site, Johnson County should receive high priority for intensive investigations aimed at discovering their suitability as summer maternity habitats for *Myotis sodalis*. (The Cedar Creek site is located on land administered by the Shawnee National Forest.)

(2) Additional investigations by mist netting streams and rivers in the Shawnee National Forest are needed to ascertain the extent to which these summer habitats are utilized by *Myotis sodalis* and *Myotis grisescens*.

(3) Additional trapping should be conducted at Cave Spring Cave to confirm its suspected usage as a bachelor and transient site by *Myotis sodalis* and *Myotis grisescens*.

(4) Additional trapping should be conducted at Rich's Cave to determine its degree of utilization by migrating *Myotis sodalis* and possibly *Myotis grisescens*.

(5) Additional caves and mines within the Shawnee National Forest should be trapped to determine their current status of utilization by *Myotis sodalis and Myotis grisescens*.

(6) Forestwide standards and guidelines for the management of *Myotis sodalis* and *Myotis grisescens* habitats, as outlined during mitigation with the U. S. Fish and Wildlife Service, Illinois Department of Conservation and Illinois Natural History Survey, should be followed until site-specific management recommendations are developed.

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